United States Patent [19]

Lauterbach et al.

[11] **Patent Number: 5,022,832**

[45] **Date of Patent: Jun. 11, 1991**

[54] **RING VALVE TYPE AIR COMPRESSOR**

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[73] Assignee: **Holset Engineering Company,** Columbus, Ind.

[21] Appl. No.: **278,225**

[22] Filed: **Nov. 30, 1988**

[51] **Int. Cl.**[5] **F04B 21/02**

[52] **U.S. Cl.** **417/571;** 137/516.15

[58] **Field of Search** 417/563, 564, 569, 571, 417/565, 279, 454; 137/576.15, 543.19

[56] **References Cited**

U.S. PATENT DOCUMENTS

2,556,623	6/1951	Lipkau	417/295
4,045,009	8/1977	Pees	137/512.15

FOREIGN PATENT DOCUMENTS

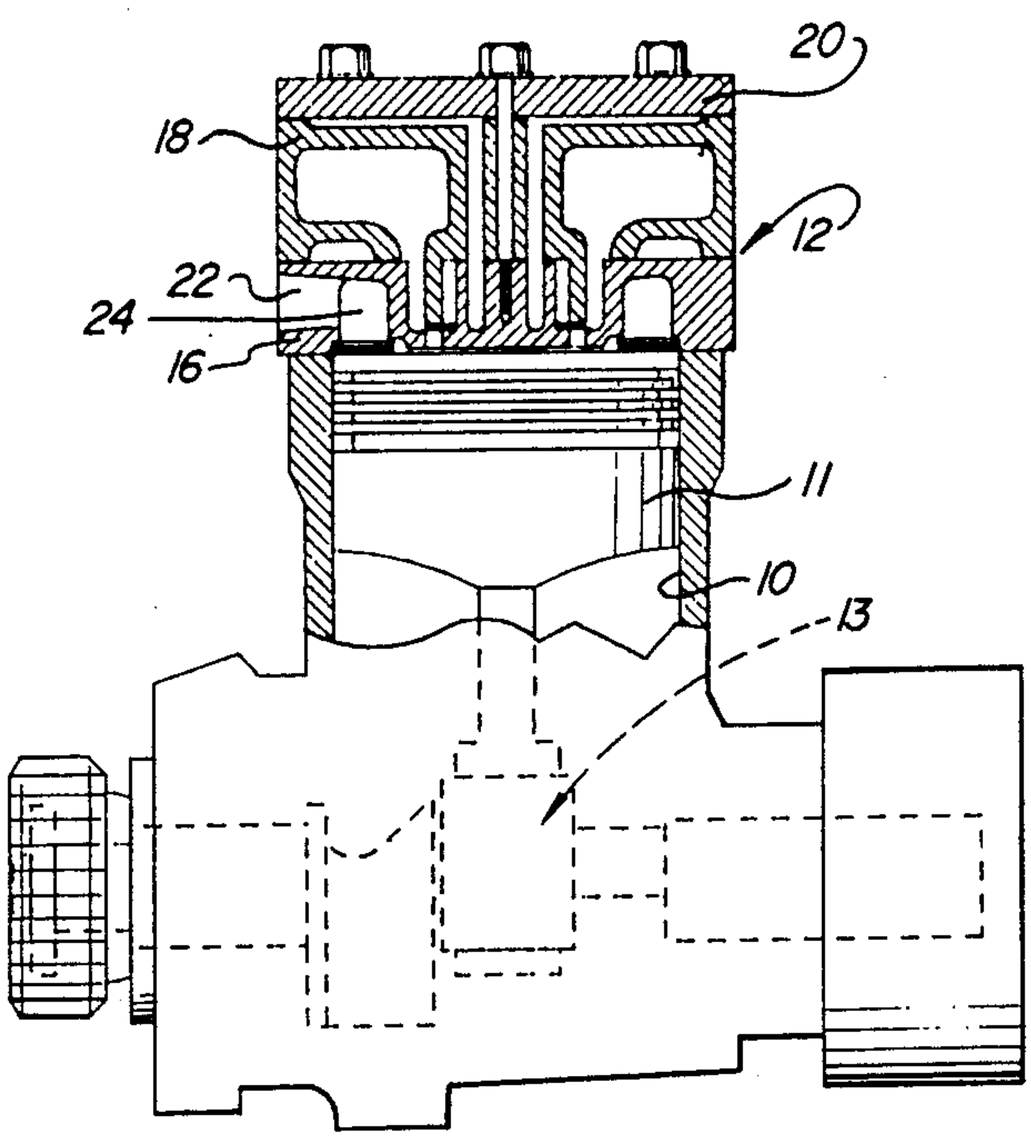
1809954	5/1970	Fed. Rep. of Germany	417/564

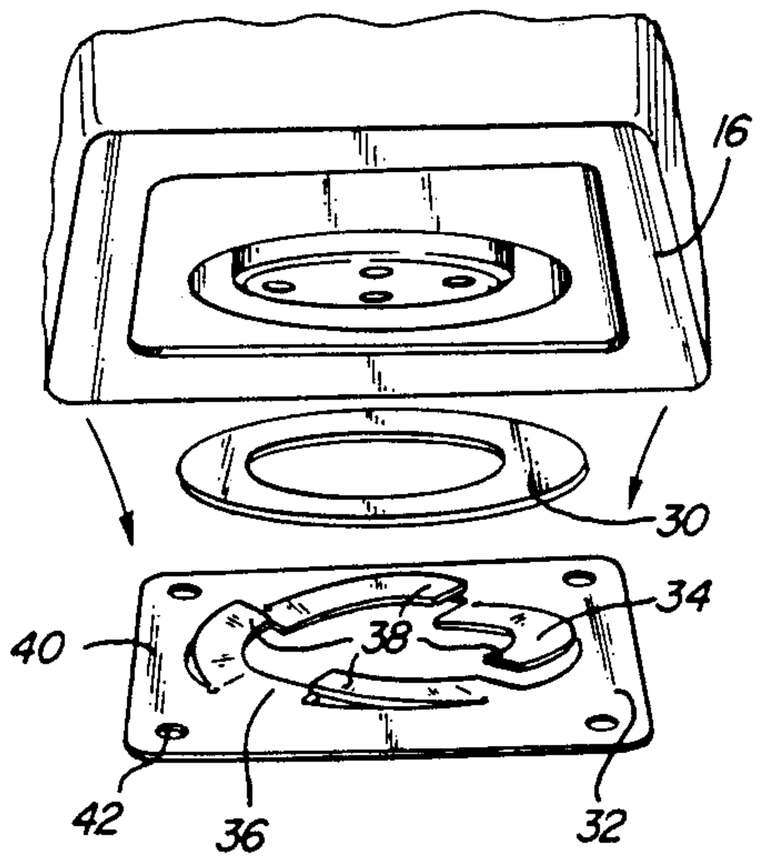
Primary Examiner—Leonard E. Smith
Assistant Examiner—D. W. Scheuermann
Attorney, Agent, or Firm—Dykema Gossett

[57] **ABSTRACT**

There is disclosed a valve assembly and a reciprocating type fluid pump having a piston cylinder and a cylinder head together which define a fluid chamber. A first ring valve having a seal surface on one side is disposed within the fluid chamber adjacent to the cylinder head to close at least one fluid intake passage. A bias means is provided for urging the first ring valve against the seat on the head by abutting the ring valve on the side opposite from the seal surface, and the bias means includes a peripheral region which is connected to the fluid pump and retains the first ring valve between the cylinder head and the bias means.

14 Claims, 5 Drawing Sheets





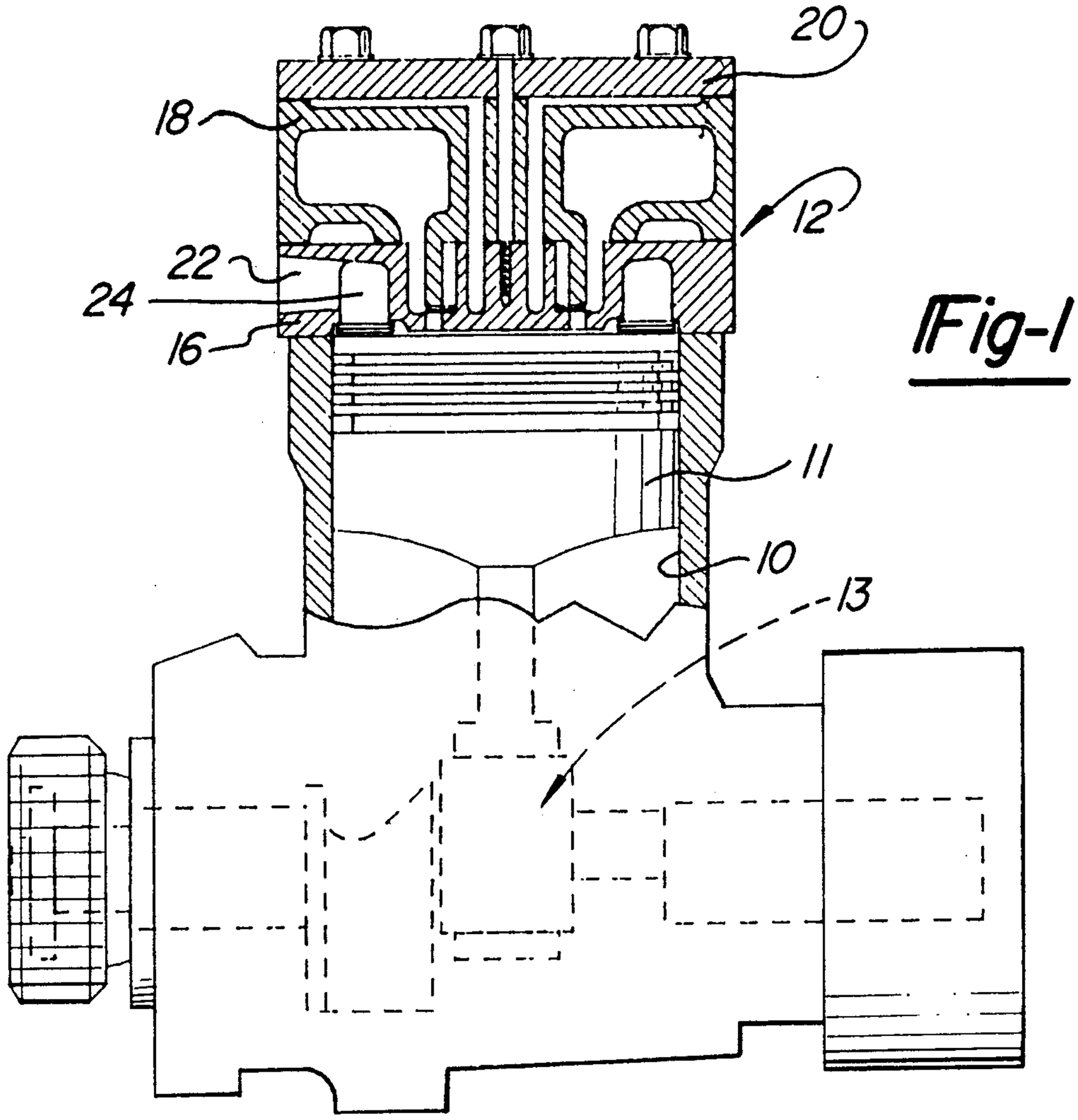

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Fig-1

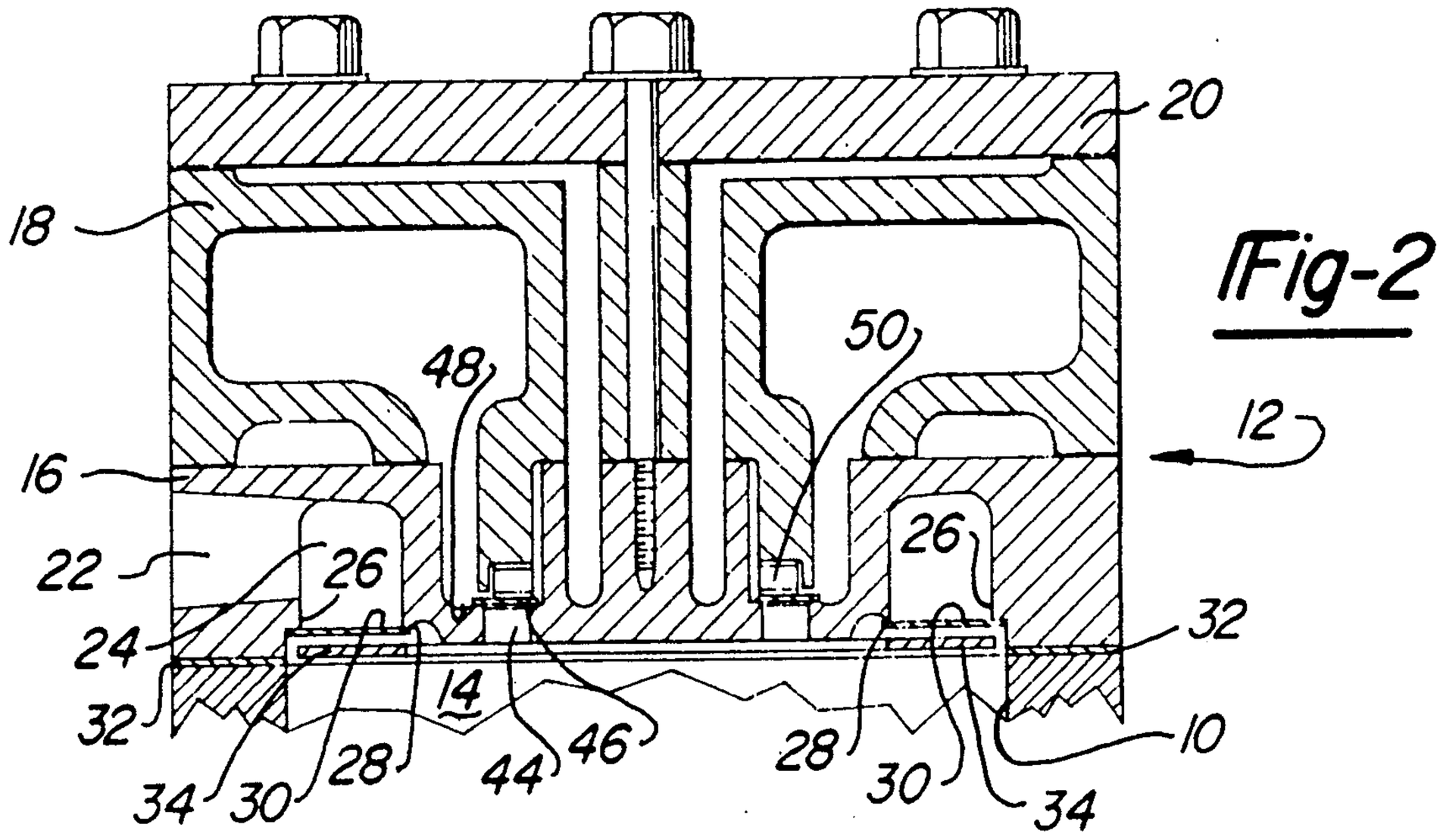
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Fig-2

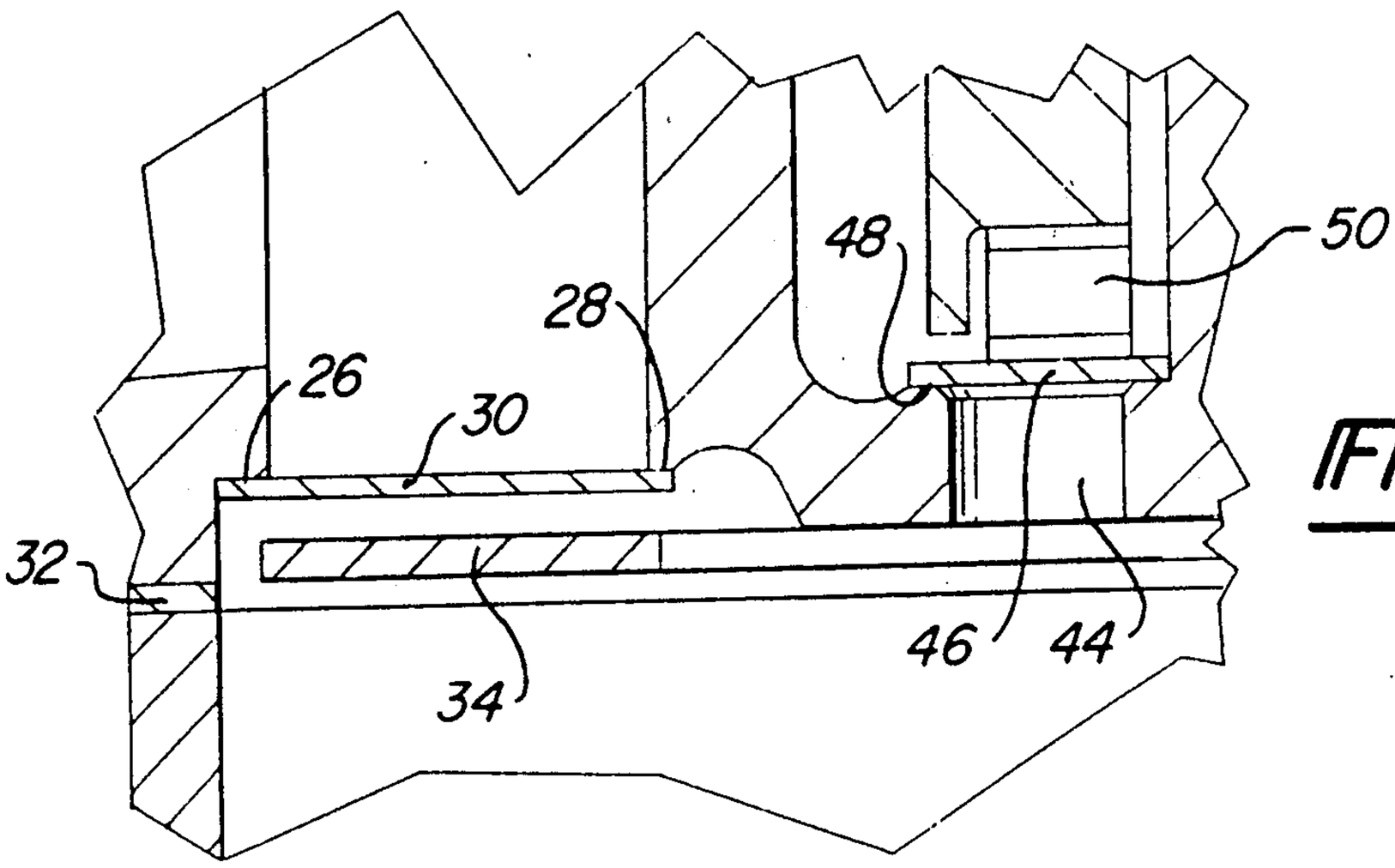


Fig-3

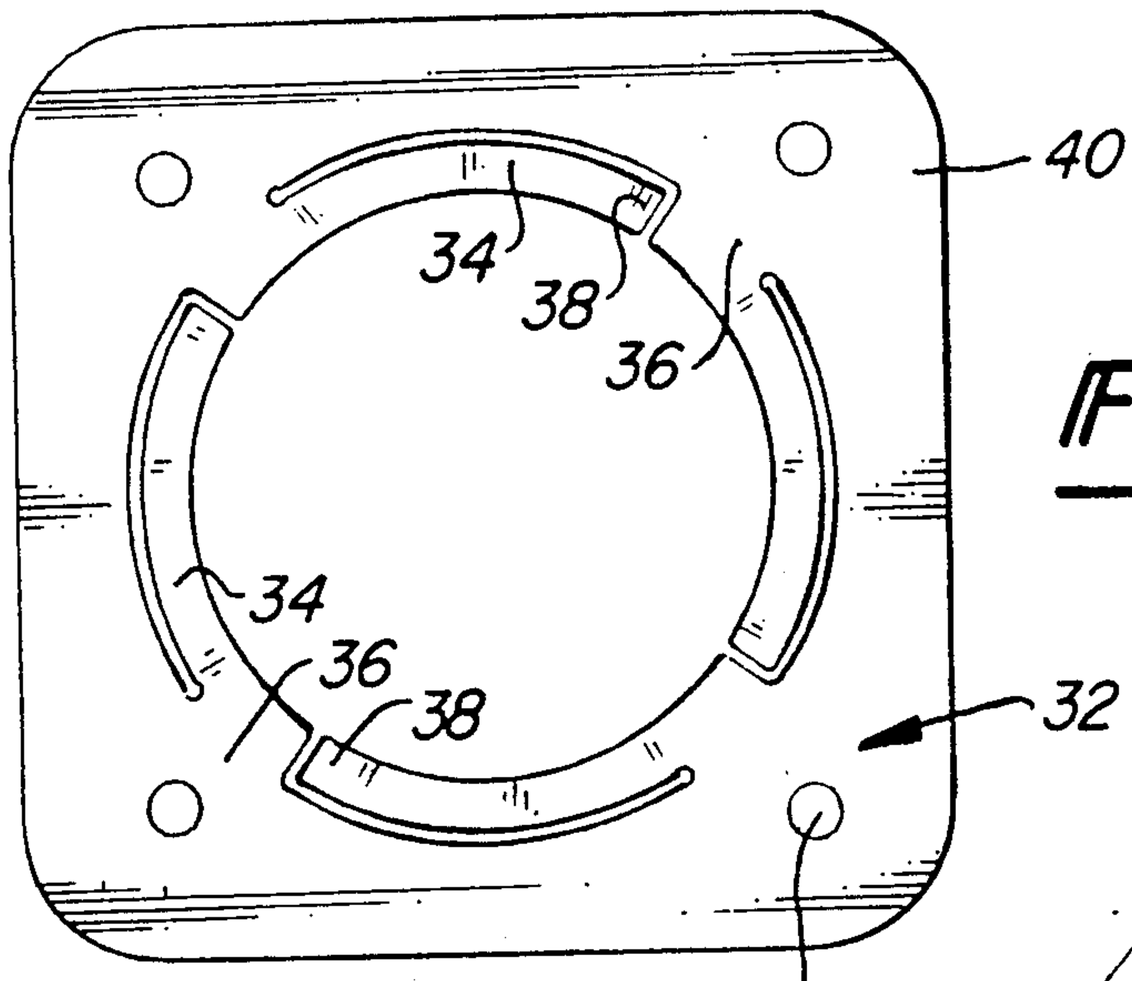


Fig-4

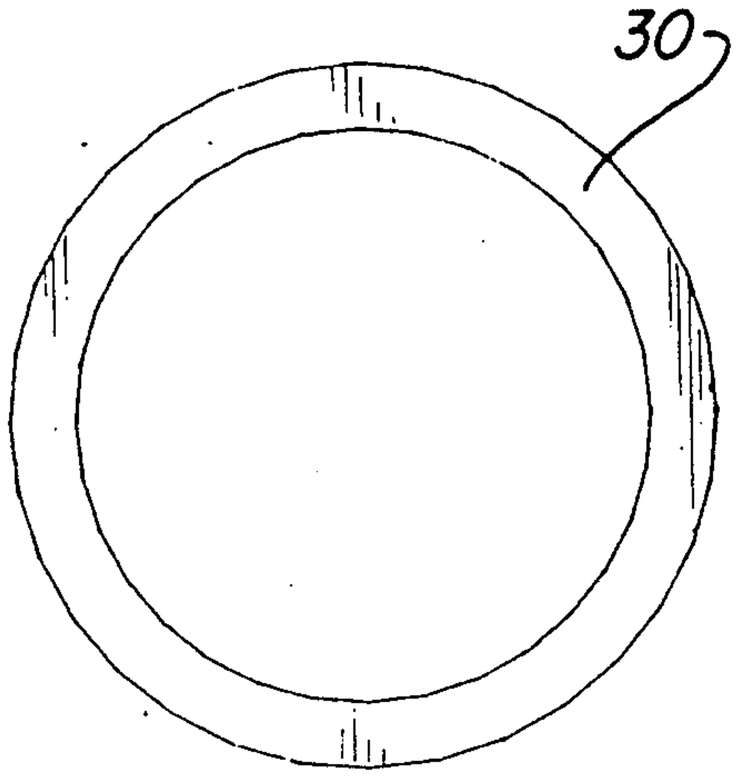


Fig-5

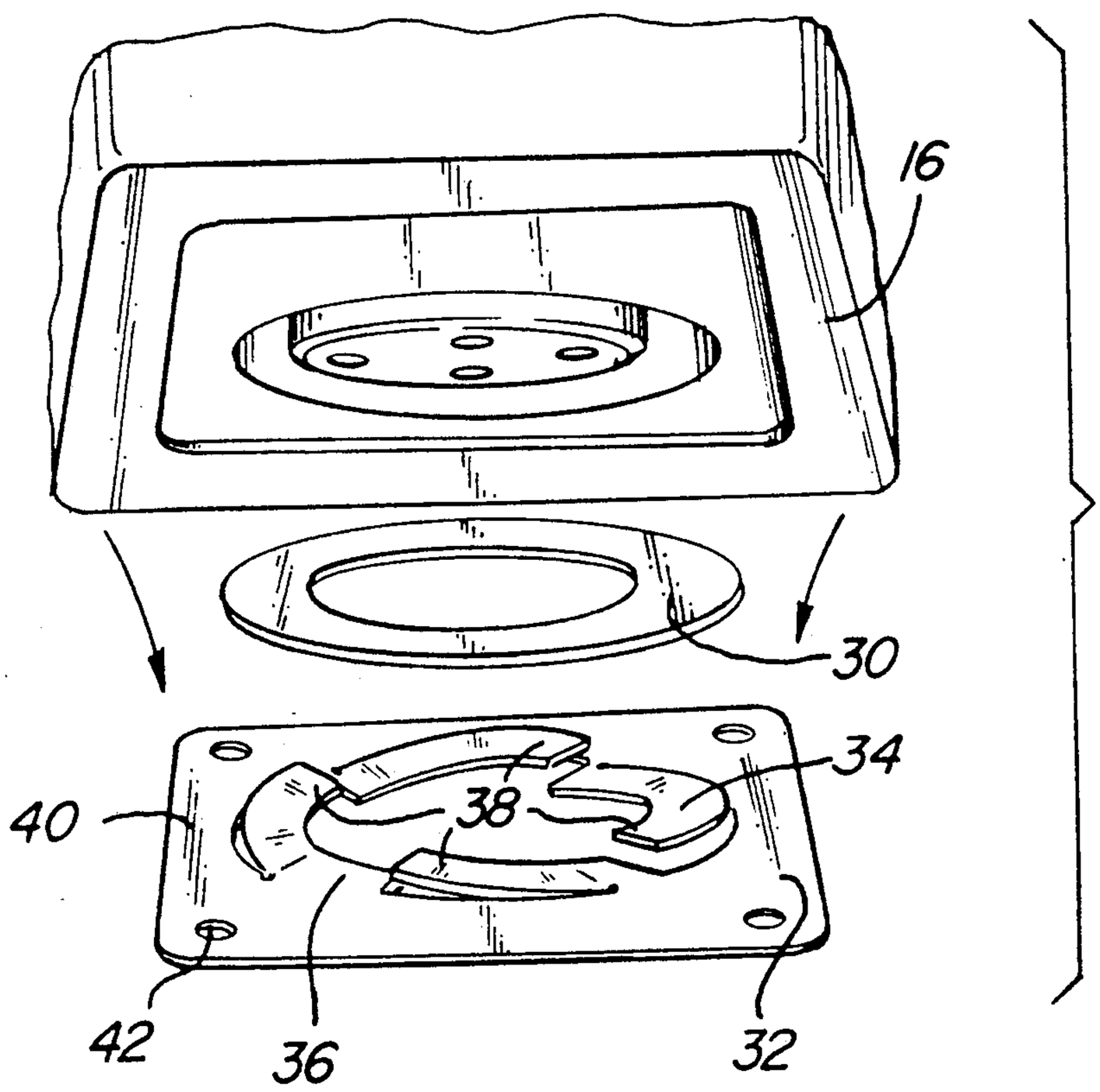


Fig-6

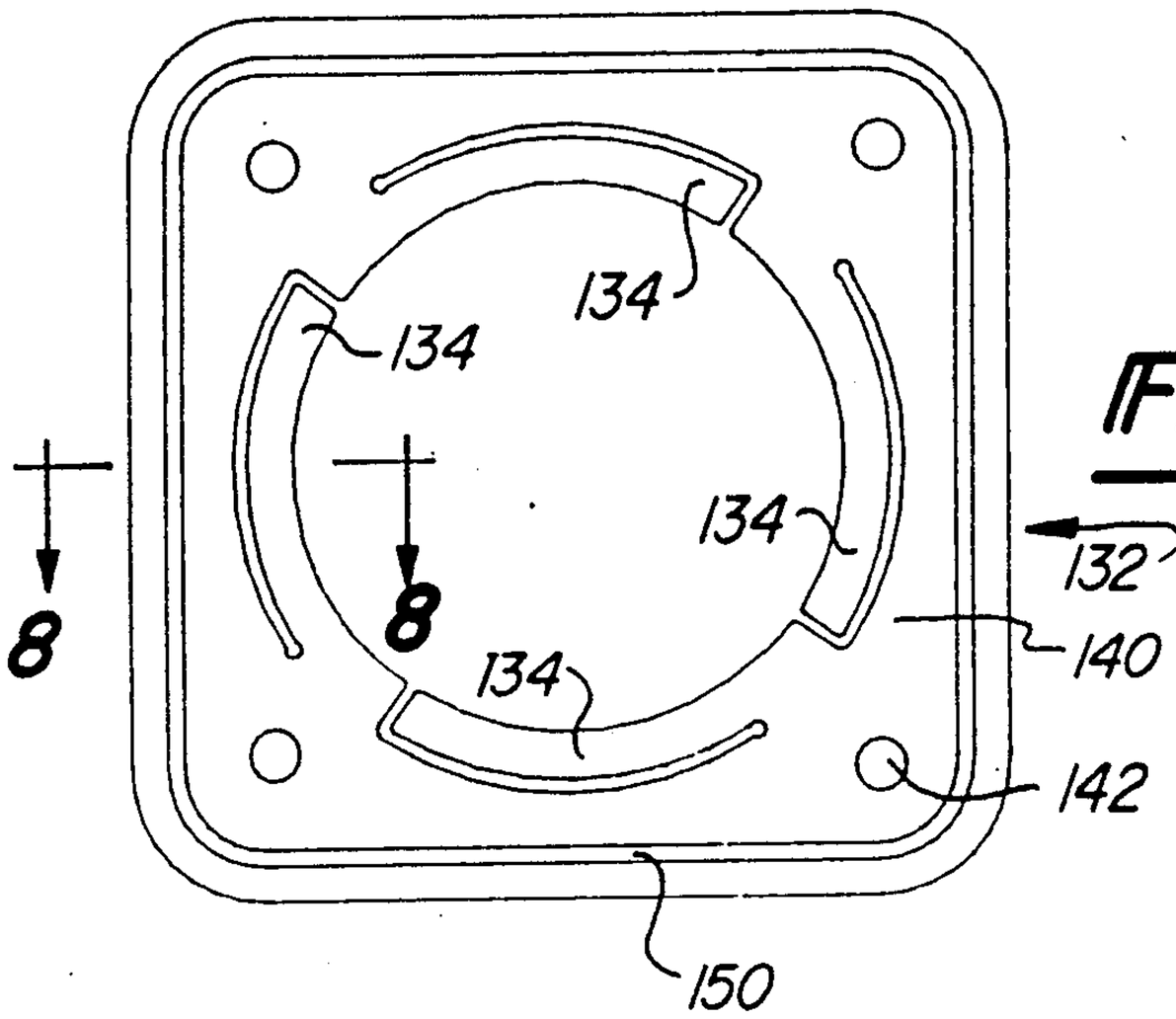


Fig-7

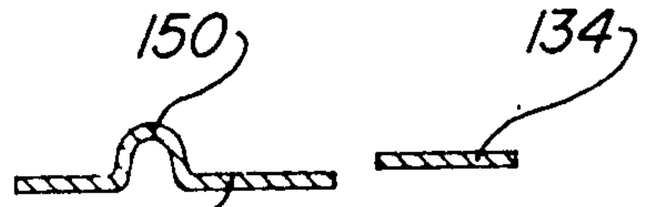


Fig-8

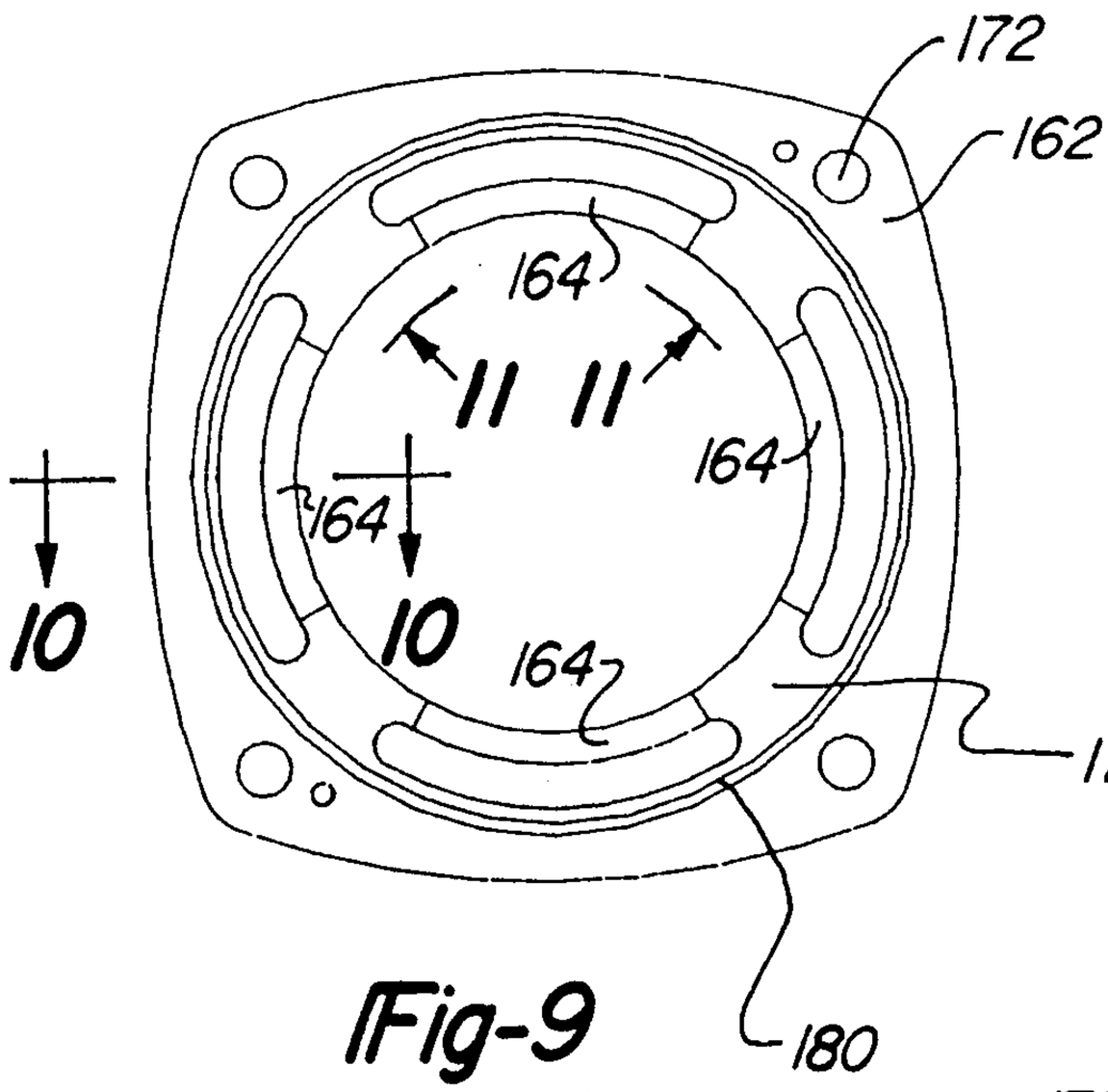


Fig-9

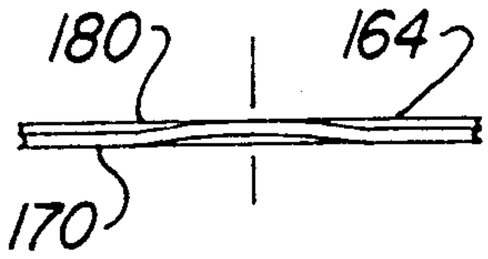


Fig-11

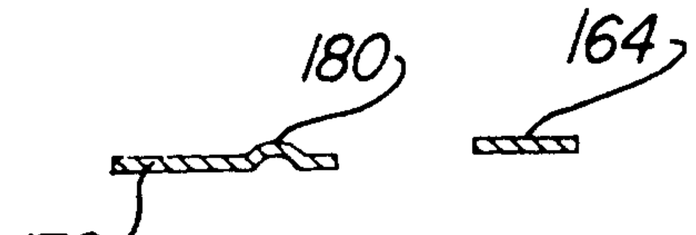
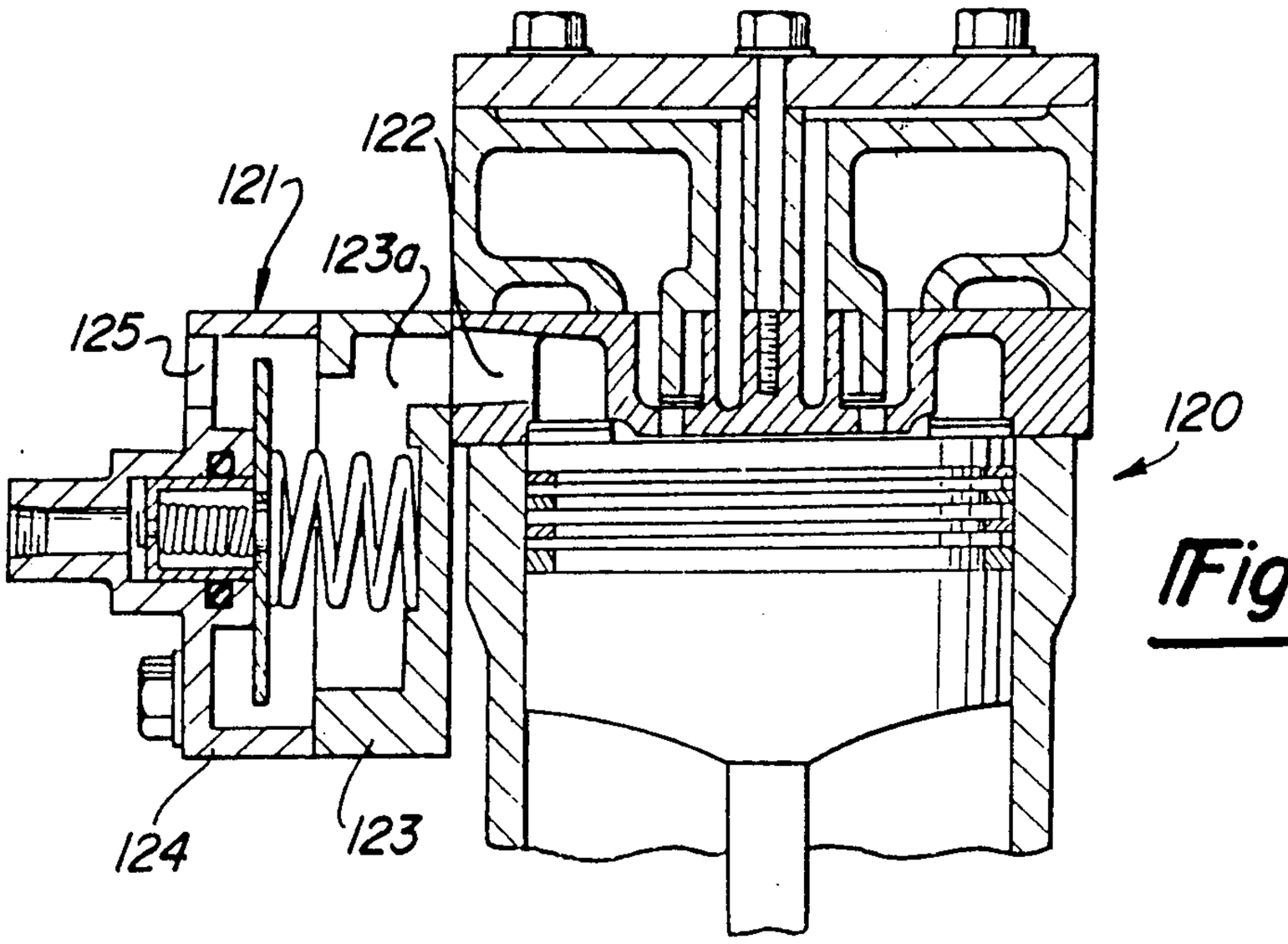


Fig-10


122
121
123a
125
120
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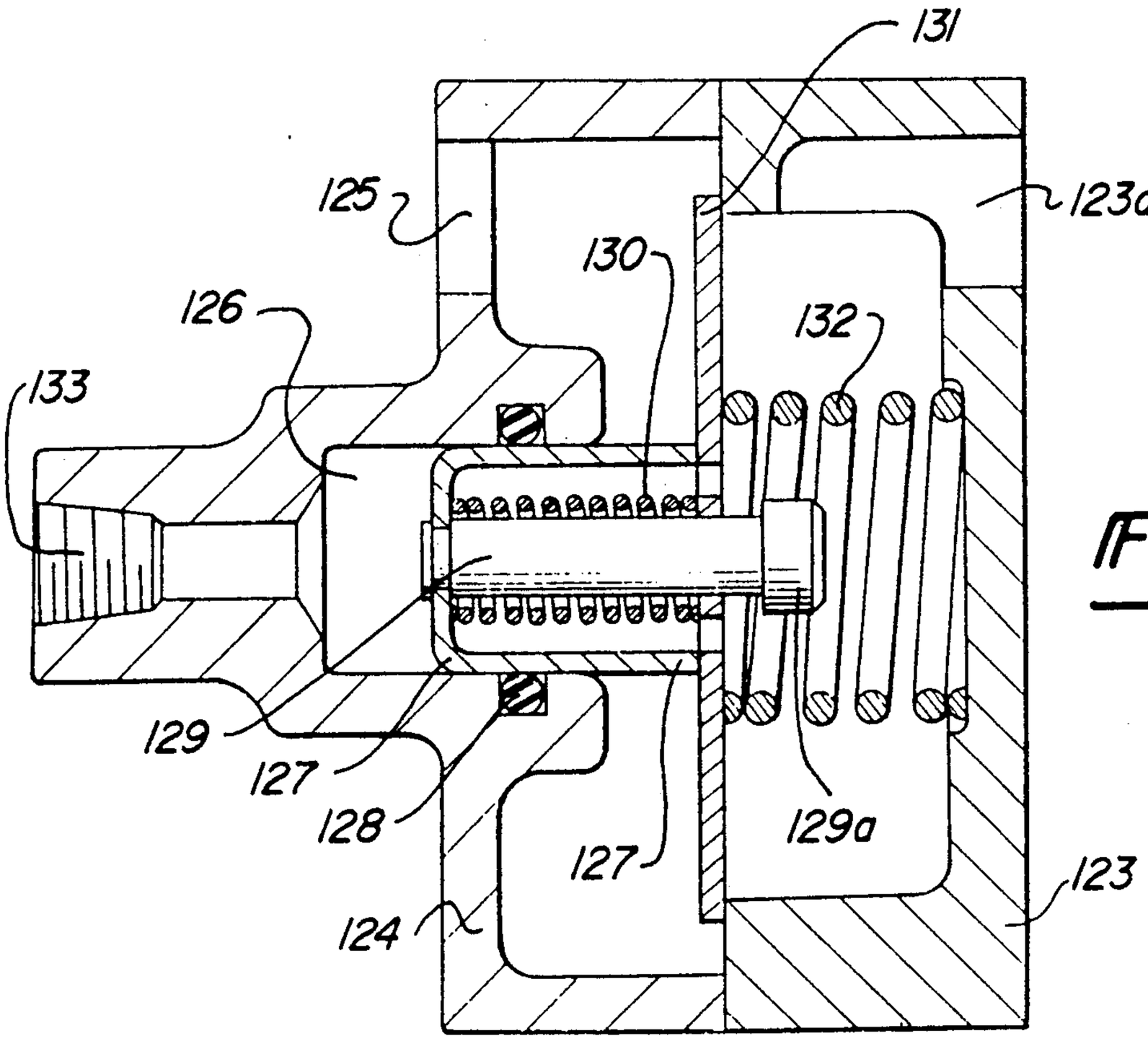
123

Fig-12


131
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128
129a
124
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Fig-13

RING VALVE TYPE AIR COMPRESSOR

BACKGROUND OF THE INVENTION

I. Field of the Invention

The present invention relates generally to valves for controlling fluid flow that operate to permit and disrupt fluid flow automatically, and particularly to ring-type valve structures, including biasing means, used as air inlet valves and exhaust valves in high pressure gas compressors and fluid pumps.

II. Description of the Prior Art

Ring-type valves per se are generally well known in the prior art, and have a wide acceptance in use for air compressors and pumps. Basically, these ring-type valves are opened and closed by pressure differential on opposite sides of the ring valve. It is also heretofore known to include biasinq of spring devices along with such ring valves in order to accurately control valve movement upon a pressure differential which is above the spring force of the spring selected in each case. In this way, the valve is opened or closed only upon reaching a predetermined pressure differential dependent on the spring properties of the spring chosen, and the mass of the valve, wherein the valve action can be predicted.

Examples of ring valves and spring devices are shown by Herzmark, U.S. Pat. No. 2,382,716, issued Aug. 14, 1915; Peters, U.S. Pat. No. 1,222,321, issued April 10, 1917; and Garland, U.S. Pat. No. 3,786,834, issued Jan. 22, 1974.

The Herzmark reference is directed to an air compressor which utilizes ring valves to control air flow between low stage and high stage air compression cylinders. Herzmark also discloses the use of spring washers that are freely supported to bias the ring valves in a desired position. This type of spring washer and ring valve requires additional supporting structure to retain the spring washer that decreases the efficiency of the air compressor by lowering the compression volume of each cylinder at the end of the suction stroke, and increases the cost, weight and complexity of the valve assembly.

The above-mentioned patents to Peters and Garland simply illustrate the conventional use of ring valves and spring devices arranged on air compressors concentrically. These references are likewise deficient in that additional support structure is needed for the valves and springs.

SUMMARY OF THE PRESENT INVENTION

The solution to the problems present in the prior are achieved by a valve assembly and reciprocating type fluid pump having a piston cylinder and a cylinder head together which define a fluid chamber. A first ring valve having a seal surface on one side is disposed within the fluid chamber adjacent to the cylinder head to close at least one fluid intake passage. A bias means is provided for urging the first ring valve against a seat on the head by abutting the ring valve on a side opposite from the seal surface, and the bias means includes a peripheral region which is connected to the fluid pump and retains the first ring valve between the cylinder head and the bias means.

Thus, it is a primary object of the present invention to provide a fluid pump device such as an air compressor that has an increased volumetric efficiency while at the same time reducing costs, weight and complexity.

It is another object of the present invention to provide a valve assembly for an air compressor including a ring valve and a spring element, wherein the spring element includes a peripheral region which is to be connected to the compressor within the compression chamber thereof for retaining the ring valve adjacent to the cylinder head of the compressor.

It is yet another object to provide the spring element with a peripheral region to be secured between the piston cylinder and the cylinder head of an air compressor, whereas the peripheral region serves as a head gasket between the aforementioned points to seal the compression chamber of the compressor. By making the spring element and the head gasket one piece instead of plural pieces, the amount of volume of the compression chamber at top dead center of the piston, at the maximum compression stroke, is decreased. This, in effect, minimizes the clearance volume between the top of the piston and the cylinder head to therefor raise the efficiency of the compressor.

It is yet another object of the present invention to decrease the manufacturing costs of a valve assembly and an associated air compressor, by providing a simple valve device which does not rely on pressure differential to operate the valve, wherein a spring element closes the valve immediately at the bottom dead center of the suction stroke.

Further objects and advantages of the present invention will be apparent from the following description and appended claims, reference being made to the accompanying drawings forming a part of the specification, wherein like reference characters designate corresponding parts in the several views.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevational view partially cut away of a ring valve type air compressor embodying the present invention;

FIG. **2** is an enlarged view of the cylinder head area of the ring valve type air compressor shown in FIG. **1**;

FIG. **3** is a further enlargement of the valve seat area of the cylinder head shown in FIG. **2**;

FIG. **4** is a plan view of a valve spring and gasket embodying the construction of the present invention;

FIG. **5** is a top plan view of the ring valve used with the present invention;

FIG. **6** is a perspective view showing how the valve spring and ring valve of the present invention are installed in the cylinder head of FIG. **2**:

FIG. **7** is a modification of the valve spring shown in FIG. **4**;

FIG. **8** is a sectional view taken in the direction of the arrows along the section line **8—8** of FIG. **7**;

FIG. **9** is a top plan view of a modification of the valve spring shown in FIG. **7**;

FIG. **10** is a sectional view taken in the direction of the arrows along the section line **10—10** of FIG. **9**; and

FIG. **11** is an elevational view taken in the direction of the arrows along the view line **11—11** shown in FIG. **9**

It is to be understood that the present invention is not limited to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments, and of being practiced or carried out in various ways within the scope of the claims. Also it is to be understood that the phraseology and terminology used herein is for the purpose of description, and not of limitation.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT OF THE PRESENT INVENTION

With reference to the drawings, and in particular to FIGS. **1** and **2**, illustrated is a valve assembly and a portion of an air compressor or fluid pump. The remaining description will refer to the unit as a compressor and valve assembly with the understanding that the valve assembly can be used on any similar type fluid pump.

Shown is a reciprocating type compressor including a piston cylinder **10** and a cylinder head **12**. Within the piston cylinder **10** is a piston **11** driven by a conventional crankshaft **13** or other suitable means. The piston, the piston cylinder bore and the head define a fluid chamber, more particularly a gas compression chamber **14**, the volume of which is varied by movement of the piston.

Air or other gas enters into the gas compression chamber by way of the cylinder head **12**, which is divided into a plurality of elements in the preferred form as in FIG. **2**. However, it is only necessary that there be a single element to provide both intake and exhaust as will be apparent from the description below. The head **12** of the FIG. **1** embodiment comprises a two part assembly with a plate **16** and a body **18** along with a cover plate **20**. Together, these elements define the air flow passages for air intake and exhaust.

At least one air intake **22** is provided in plate **16** which opens into a gallery **24** also formed in plate **16** and which provides a circular channel on the bottom face of plate **16** for better distribution of intake air into the gas compression chamber **14** by way of an intake valve, as hereinafter described. The gallery **24** is further defined on the outer face of the plate **16** by an outer circular ridge **26** and an inner circular ridge **28**. The outer and inner ridges together serve as a valve seat for the intake valve comprised of a ring valve **30**. The ring valve **30** includes a seal surface on one side thereof to contact the valve seat and thereby close off the intake air from the gas compression chamber **14**. Ring valve **30** is illustrated in FIG. **5** and is dimensioned so as to completely cover the gallery **24** as defined between the inner and outer ridges **28** and **26** respectively. The ring valve and gallery together present a simple design with a high flow area.

Disposed adjacent to the ring valve **30** is a spring element **32** to bias the ring valve **30** against its seat defined by ridges **26** and **28**. The spring element **32**, seen most clearly in FIGS. **4** and **6**, comprises a substantially flat plate-like member of rectangular configuration with a circular opening therein. Within the circular opening are four spring arms **34** which are connected to the spring element **32** at **36**. Preferably, the spring arms **34** can be provided on the spring element wherein four are used in the preferred embodiment. The spring arms **34** extend from connection points **36** toward distal ends thereof at **38**, and the spring arms also extend outward from the plane of the spring element **32** in increasing distance toward the distal ends. As shown in FIG. **6**, the spring arms **34** extend out of the plane of the page toward the viewer with the distal ends **38** of each spring arm out substantially the same distance.

The spring element **34** further comprises a substantially flat peripheral region **40** completely surrounding the spring element **32**. This peripheral region **40** serves the dual purpose of connecting the spring element **32** to the air compressor to retain the ring valve **30** between the head and the spring element, and also to serve as a head gasket between the head **12** and the piston cylinder **10** to seal the gas compression chamber **14** from outside air. The spring element **32** along with spring arms **34** and the peripheral region **40** obtains a very simple construction which forces the ring valve **32** in operative position as well as sealing the gas compression chamber. Holes **42** are also provided through the peripheral region to facililtate bolts (not shown) for securing the head to the piston cylinder.

Returning to FIGS. **2** and **3**, there is an exhaust passage **44** through plate **16** of head **12** which is closed off by a second ring valve **46**. The ring valve **46** is provided on the opposite side of the head plate **16** and contacts a seat **48** on the plate **16**. The second valve **46** is biased toward the seat in a closed position by a spring means **50**. The spring means **50** can be any conventional spring such as a single spiral spring, a plurality of small spiral springs, a leaf spring or springs, or a spring device similar to that shown in FIG. **4** without the gasket region. Likewise, the ring valve **46** is similar to that shown in FIG. **3**, but is dimensioned to seat entirely with seat **48** and seal the exhaust passages from the gas compression chamber **14**.

The operation of the valve assembly and air compressor is described as follows, starting at the point in a reciprocating compressor wherein the piston **11** is at top dead center. As the piston is moved away from the head, suction is created in the gas compression chamber **14** thus opening ring valve **30** against the bias of spring arms **34**. Air thus enters the compression chamber by way of intake **22**, gallery **24** and ring valve **30**. When the piston reaches bottom dead center, the bias of the spring arms **34** effectively closes off the intake **22** and seals the compression chamber from the intake. The present invention thus operates to close off the intake air immediately at the bottom dead center of the suction stroke without having to rely on pressure differential to operate the ring valve. Thereafter, during the compression stroke or the piston, the intake ring valve **30** remains closed and the pressure within the compression chamber opens the exhaust ring valve **46** against the bias of spring means **50**. By making the spring element and the head gasket of a single piece instead of plural pieces, the amount of volume of the compression chamber at top dead center of the piston, at the maximum compression stroke is decreased. This, in effect, minimizes the clearance volume between the top of the piston and the cylinder head to therefor raise the efficiency of the compressor.

A further embodiment of a spring element is shown in FIGS. **7** and **8** at **132**. This embodiment is basically the same as the spring element **32** including spring arms **134** and mounting holes **142** with an additional feature to improve the sealing capability of the gasket portion at the peripheral region **140**. For this purpose, a crimp **150** is provided in the peripheral region **140** to extend along the peripheral region. Although it is shown that the crimp **150** extends entirely along the peripheral region, it is also possible to provide the crimps at only selected regions where increased sealability is desired. FIG. **8** simply shows a cross section along line **8—8** of FIG. **7** with the crimp **150** extending above the substantially flat plane of the peripheral region **140**. The crimp **150** is positioned such that when the peripheral region is used as a head gasket between the piston cylinder and head, the crimp is subjected to the force applied by the head bolts and is compressed between the piston cylinder and

the head, thereby increasing the seal of the gasket. It is also contemplated to use a bead of sealant along with the gasket to increase the seal of either the gasket with or without the crimp. Any type conventional sealant such as RTV can be used.

A still further embodiment of a spring element is shown in FIGS. **9–11** at **162**. This element is still basically the same as the spring element **32**, but including integral spring arms **164** and mounting holes **172** with an additional feature to improve the sealing capacity of the gasket portion, as in the embodiment shown in FIG. **7**, at the peripheral region **170**. For this purpose, a crimp **180** is provided in the peripheral region **170** to extend along the peripheral region. Although it is shown that the crimp **180** extends entirely along the peripheral region, as before, it is also possible to provide the crimps at only selected regions where increased sealability is desired. FIG. **10** simply shows a cross-section along line **10—10** of FIG. **9**, with the crimp **180** extending above the substantially flat plane of the peripheral region **170**. The crimp **180** is positioned such that when the peripheral region is used as a head gasket between the piston cylinder and head, the crimp is subjected to the force applied by the head bolts, and is compressed between the piston cylinder and the head, thereby increasing the seal of the gasket, as with the embodiment shown in FIG. **7**. It is again contemplated to use a bead of sealant along with the gasket to increase the seal of either the gasket with or without the crimp. As before, any type of conventional sealant such as RTV can be used.

Further in regard to plate **16** of the head **12**, a high silicon aluminum alloy with more than 11 per cent silicon is preferably used to form the plate **16**. It has been found that such a high silicon plate with the valve seats **26**, **28** and **48** formed thereon has an increased hardness and increased wear resistance. Preferably, the plate is **die cast with an alloy of approximately 18% silicon.**

The valve assembly of the present invention is applicable to air compressors of any size that use a reciprocating motion to compress air, as well as to the compression of any other gases, such as refrigerant compressors. It is also within the scope of the present invention to use such a valve assembly on other types of fluids other than gases which may, or may not, be compressible, such as for liquid pumps.

As can be seen by referring to FIGS. **12** and **13**, our improved compressor can accept an external loading unloading device **121** to enable it to be used in compressor unloading systems preferably of the type disclosed in our co-pending United States Letters Patent application 07/278,17D entitled "Air Compressor Unloader System" filed on even date herewith and under common ownership with the present application. As can be seen, there is provided an air manifold **123** adapted to fit over and enclose the intake **122** of the ring valve type air compressor **120**. A valve body **124** having an inlet **125** is mounted to the air manifold **123** to completely enclose the internal cavity **123***a* provided in said manifold. A cylinder **126** is formed in the valve body **124** in which is sealingly but slidably fitted a piston **127** having a piston rod **129** fixedly mounted thereto. A valve **131** is retained on the piston rod between the valve unloader spring **130** and the enlarged end **129***a* of said piston rod. As the piston **127** reciprocates in the cylinder **126**, the valve **131**, will also reciprocate opening and closing the internal cavity **123** of the air manifold, and therefore blocking and unblocking the fluid communication between the inlet **122** of the air compressor and the atmosphere. To assist the movement of the valve **131**, valve spring **132** is interposed between the valve **131** and the manifold **123**.

We claim:

1. A valve assembly and reciprocating fluid pump having a piston cylinder and a cylinder head secured to said piston cylinder defining a fluid chamber, said valve assembly comprising:

a) a first ring valve with a seal surface on one side thereof disposed adjacent to said cylinder head to selectively engage a seat means on said cylinder head and close at least one fluid passage through said cylinder head; and

b) a bias means for urging said first ring valve against said seat means on said cylinder head by abutting said first ring valve on a side opposite from said seal surface;

wherein said bias means includes a peripheral region connected to said fluid pump, wherein said peripheral region of said bias means is connected to said fluid pump between opposing faces of said piston cylinder and said cylinder head and serves as a gasket for said fluid chamber, and said bias means retains said first ring valve between said cylinder head and said bias means.

2. The valve assembly of claim **1**, wherein said peripheral region and said opposing faces of said piston cylinder and said cylinder head are substantially flat.

3. The valve assembly of claim **1**, wherein said peripheral portion includes a crimp along at least a partial distance thereof to increase the seal of said gasket.

4. The valve assembly of claim **1**, further comprising a circular gallery formed on said cylinder head which is defined between an inner and an outer circular ridge, and said inner and outer ridges provide said seat means on said cylinder head;

whereby said gallery improves fluid flow through said valve assembly by distributing the fluid flow along the seat means to be opened and closed by said first ring valve.

5. The valve assembly of claim **1**, wherein said bias means has a plurality of spring arms for abutting and urging said first ring valve against said seat means, and said spring arms are connected to an internal edge of said peripheral region.

6. The valve assembly of claim **5**, wherein said spring arms are formed integrally with said peripheral region, and said spring arms extend away from the plane of said peripheral region toward said cylinder head to distal ends which abut said ring valve.

7. The valve assembly of claim **1**, wherein said fluid pump is a gas compressor and said fluid chamber is a compression chamber.

8. The valve assembly of claim **1**, wherein said cylinder head and seat means are composed of a high silicon aluminum alloy with more than 11 per cent silicon for increased wear resistance.

9. The valve assembly of claim **1**, further comprising a second ring valve disposed coaxially with said first ring valve and adjacent to said cylinder head on the side opposite to said fluid chamber for selectively closing an exhaust passage provided through said cylinder head, and a second bias means for urging said second ring valve to a closed position with respect to said exhaust passage.

10. A ring valve reciprocating type fluid pump having a piston cylinder and a cylinder head with an intake and an exhaust passage therethrough secured to said

piston cylinder defining a fluid chamber, said valve assembly comprising:

a) a first ring valve disposed adjacent to said cylinder head on the fluid chamber side thereof for selectively closing said intake passage:

b) a first bias means within said fluid chamber for urging said first ring valve toward a closed position:

c) a second ring valve disposed coaxially with said first ring valve and adjacent to said cylinder head on the side opposite to said fluid chamber for selectively closing said exhaust passage:

d) a second bias mans for urging said second ring valve toward a closed position:

e) wherein said first bias means includes a peripheral region that is connected to said fluid pump between said cylinder head and said piston cylinder and serves as a gasket for sealing the fluid chamber, and said first bias means is connected to said fluid pump so as to retain said first ring valve between said cylinder head and said first bias means, and said first ring valve and said first bias means are directly exposed to said fluid chamber.

11. The fluid pump defined in claim **10**, wherein said fluid pump is a gas compressor and said fluid chamber is a compression chamber.

12. The fluid pump defined in claim **10**, and including an external unloading device for said fluid pump.

13. The device defined in claim **12**, wherein said external unloading valve includes:

a) a manifold to be sealingly mounted over the intake of said fluid pump and having an internal cavity communicating with the intake of said pump; and

b) a valve body including valve means selectively operable to open and close said internal cavity of said air manifold.

14. The device defined in claim **13** wherein said valve body includes:

a) an internal passage communicating with said internal cavity of said manifold;

b) a valve member disposed in said internal passage for movement between an open and closed position and disposed to block said internal cavity of said air manifold when in said closed position;

c) a cylinder formed in said valve body ;

d) a piston slidably and sealingly mounted in said cylinder;

e) a piston rod connecting said cylinder and said valve;

f) an unloader spring interposed between said piston and said valve:

g) a second spring means interposed between said manifold and said valve; and

h) an unloader port in communication with said cylinder.

* * * * *